The Kingdom of Sweden

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Inhabited during the Stone Age, several independent tribes lived in Sweden by the 9th century A.D. During that time, those adventurous tribes were among the Scandinavians known as the Vikings. Loosely united and converted to Christianity a couple centuries later, the Swedes conquered the Finns; they joined Norway and Denmark, and finally broke away in 1537 under Gustav I Vasa. Sweden became a constitutional monarchy in 1809.

Sweden is mostly flat with gently rolling lowlands; there are mountains in the west along the Norwegian border, and the kingdom is slightly larger than California. The lowest point is the reclaimed bay of Lake Hammarsjon, near Kristianstad (-2.41 m); the highest point is Kebnekaise (2,111 m).

According to the *Lantmäteriet*, "The '*geometriska jordeböcker*' are the oldest large-scale maps in Sweden. One of the main tasks of the Land Survey following its establishment in 1628 was to carry out the mapping of villages and individual farms and their lands. It was primarily Crown farms that were the focus of interest. Cultivated fields and meadowland were mapped and information concerning yields and other information related to income and economic matters was collected. It is not clear whether the original purpose of the mapping was, in fact, to form the basis for taxation, but it can definitely be seen as the predecessor to the Swedish land use maps (*Ekonomiska kartan*). The maps are unevenly distributed across Sweden. They are collected in large volumes sorted according to parish and district. The '*geometriska jordeböcker'* should not be confused with the Crown's standard '*jordeböcker*' which cover landed properties and contain fiscal information about them. The Crown's '*jordeböcker*' can be looked upon as being the first Swedish real property register and the '*geometriska jordeböcker'* as the first cadastral index maps. There are around sixty volumes for the period between 1630 and 1650. Most of the maps are at a scale of 1:5000. We have only included in this series the volumes that have been scanned and are in digital format. To find older '*geometriska jordeböcker*' which are not yet scanned, you should go to the series Cadastral Maps. In The Land Survey map archives there are more than a hundred volumes of maps titled '*geometriska jordeböcker*' dating from the latter half of the 1600s and the early part of the 1700s. The maps are at varying scales, although most of them are large-scale maps. They mainly comprise farm maps that were produced for taxation purposes, maps to be used as the basis for the recruitment of and provision of material support of soldiers, and maps needed for the organization of the return of land by the Church to the Crown."

During the early 18th century, the French scientist, Maupertuis joined with the Swedish astronomer, Celsius on the French expedition to Lapland for the determination of the length of a degree of the meridian arc. This was considered an expedition for insurance in case the sister trip to South America (Ecuador, *PE&RS* May 1999), was not conclusive in proving the shape of the Earth. The area chosen for the chain of north-south triangles is now the southern land border between Sweden and Finland. Starting at the Lutheran church steeple in the city of Torneå (Torne) on the Gulf of Bothnia, the chain extended northwards along the Torne River to the (now) Finnish town of Pello. Maupertuis published his book on the Lapland expedition in 1737.

Soon after the commencement of the constitutional monarchy, the military survey of the kingdom was begun in 1811. Sweden gave up Swedish Pomerania in return for Norway, which entered into a personal union with Sweden (1814-1905). A civilian mapping authority for the compilation of an economic map was formed in 1859. The military and civilian mapping agencies were consolidated in 1894 and was known as the *Rikets Allmänna Kartverk* (RAK). After a series of consolidations and mergers, the current national mapping organization of the National Land Survey (*Statens Lantmäteriet*) was formed in 1985.

According to a personal communication from Dr. Lars Sjöberg of 7 November 1980, "The first systematic triangulation of Sweden started in 1805. All calculations were made on the ellipsoid, for Northern Sweden on Svanberg's ellipsoid and for Southern Sweden on Clarke 1880. For official maps (in general scale 1:100,000) Spens' projection, was used for Southern Sweden (up to Lat 61° 30') and a conform conic projection for Northern Sweden. In 1903 a new triangulation started in Southern Sweden. The calculations were made in plane coordinates (x, y) (Gauss-Hannover's projection and Bessel's ellipsoid). The scale in the net was determined from a Danish baseline, which was measured in 1838. A new measurement of the baseline was made in 1911 and that measurement differed significantly from the earlier one. In 1938, when 5 Swedish baselines and 6 azimuths had been measured, the scale and orientation of the nets (obtained from the above measurements) were compared. The measurements of the Swedish baselines agreed better with the 1911 measurements than with the observations of 1838. It was then decided to enlarge the net with a factor 1.00002 and turn it clockwise 0.00005 radians around a point in Southern Sweden. Up till then all calculations had been made in 6 different zones with the longitude of origin referring to '*Stockholms gamla observatorium'* (The Old observatory of Stockholm), which is 18° 03' 29.8" E of Greenwich. The longitude of origin for each zone was 6° 45' W, 4° 30' W, 2° 15' W, 0°, 2° 15' E, and 4° 30' E of Stockholm's *gamla observatorium*. This system is still in use for large scale maps. *[Ed's. note: this letter from Dr. Sjöberg was dated 1980.]* In 1938, *Rikets Allmänna Kartverk* decided to reduce the number of projection zones to 3, namely 2° 15' W, 0°, and 4° 30' E for official maps with FE 1,500,000 m, 2,500,000 m and 3,500,000 m, respectively. In 1945, RAK decided to use only one projection zone for official maps namely 2° 15' W with FE 1,500,000 m. Common for all zones are that latitude of origin is 0° and FN is 0. The scale factor along the central meridian m_o is 1.0000. For some official maps there is also a grid net in the UTM projection. This net is based upon the European Datum 1950 with m_o = 0.9996 and FE 500,000 m."

I later wrote back to Dr. Sjöberg in July of the following year and inquired about the Spens projection. In Dr. Sjöberg's reply of 7 August 1981, "The Spens projection differs somewhat from the Lambert conic projection. Spens' projection satisfied the following conditions:

1. The scale factor (m_o) along the parallels φ_1 = 65° 50' 20.4" and φ_2 = 55° 21' 19.4" are equal.
2. The minimum scale factor between φ_1 and φ_2 equals m_o^{-1}.

The first condition yields log n = 9.9407276–10 and φ_o = 60° 44' 29.6"

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(These are Spens' results from 1817 used in the tables of Spens projection. The correct values are log n = 9.94072828–10 and φ_o = 60° 44' 30.2".) From the second condition one obtains m_o = 0.997903542. The x-axis of the Spens projection is the meridian 5° W of the Old Observatory of Stockholm, directed southward. The origin is located at the parallel circle 72°. The Spens projection was described by P.G. Rosen (1876) in *Den vid Svenska Topografiska Kartverket använder projektionsmetoden*, 32 pp. As far as I know there is no word '*Gradblätterkarten*.' '*Karten*' means maps and '*Gradblätter*' 'degree maps.' However I think you refer to the polyconic projection used for the old '*Generalstabskarten*' in the north of Sweden. This means that the conic projection is used repeatedly at each ½° parallel. Each map is made as a '*Gradblatt'* limited by parallel circles of every ½° and meridian of equidistance 1½°. Clarke's ellipsoidal parameters were used. The arc-triangulation in Lappland (Tornedalen) carried out in 1730-1736 under the supervision of the Paris Academy was repeated in 1801-1803. From these latter measurements Svanberg computed the Earth dimensions (published 1805)."

According to a paper published (in German) by Professor im Generalstabe Karl D. P. Rosén, Stockholm 1933, the Svandberg ellipsoid parameters used were a = 6,376,797 m and $1/f$ = 304.2506. Similarly, the published parameters for the Clarke 1880 ellipsoid as used for the Northland projection were a = 6,378,249.2 m and $1/f$ = 293.465. The specific formulae used in Sweden were discussed in 1951 by G.A. Rune in *Tabeller Till Gauss Hannoverska Projektion, Tables for Gauss's Hanoverian Projection* where he states (in English) in the Preface, "For facilitating the computation of the modern triangulation of Sweden, begun in 1903, the General Staff professor of that time Dr. Karl D. P. Rosén introduced the Gauss's Hanoverian projection, often called the Gauss-Krüger or, briefly, the Gauss's projection, a projection well fitting Sweden with it marked extension in the meridian." Note that the defining parameters of the Bessel 1841 ellipsoid are: a = 6,377,397.155 m and $1/f$ = 299.1528128. All of the Swedish classical datums have the same origin at the Old Stockholm Gamla Observatory where: Φ = 59° 20' 32.7" N and Λ = 18° 03' 29.8" E. The triangulation of Sweden from 1903-1938 consisted of 170 triangles and was observed with Wanschaff and Hildebrand instruments achieved an average Ferrero's formula accuracy of 0.41". The later Swedish triangulation of 1939-1953 consisted of 222 triangles and was observed with Wild T-3 theodolites and achieved an average Ferrero's formula accuracy of 0.40". That classical triangulation is defined as the RT 38 (*rikstrianguleringen* 1903-1950) datum. It has been replaced with RT 90 also called *Rikets Koordinatsystem* 1990, which is a local geodetic datum based on the Swedish third national triangulation (1967-1982), and is also referenced to the Bessel 1841 ellipsoid. The corresponding plane coordinate system is denoted **NT 90 2.5 gon V 0:-15** and is obtained by a Gauss-Krüger Transverse Mercator projection of the RT 90 latitudes and longitudes. The Central Meridian is λ_o = 15° 48' 29.8" E, the scale factor at origin m_o = 1.0, and FE = 1,500 km. The Central Meridian was originally interpreted as "2.5 Gon West of the Old Observatory of Stockholm," but is now defined as relative to Greenwich (1 Gon = 0.9 degrees).

According to the *Lantmäteriet*, "The original map sheet system in Sweden is based on a grid in RT 90 2.5 gon V 0:-15 with the SW corner at (North. = 6100 000 m, East. = 1200 000 m), and NE corner at (North. = 7700 000 m, East. = 1900 000 m). This area is divided into 50 km squares, which are enumerated with 0 - 32 in South-North direction, and lettered with A - N in West-East direction. Each 50 km square can be subdivided into four 25 km topographic map sheet squares, or subdivided into 100 5×5 km cadastral map sheets, which are enumerated from South to North by 0 - 9. and lettered from West to East by a - j. This original basic map sheet system has been modified in several ways for the modern series of maps, but the basic grid square notation is still frequently used, for instance in the numbering of geodetic control points. For larger scale mapping (>1:10000) there are six different zones of Transverse Mercator projections used in Sweden, in order to reduce the map projection errors. The other 5 zones apart from '2.5 gon V' differ only in the longitude of the central meridians, which are spaced by 2° 15'. The boundaries of the projection zones are adjusted to follow administrative borders if possible. The coordinate system 'RT 90 5 gon V 61:-1' has the map projection parameters: Central meridian: 13° 33' 29".8 East Greenwich, False Easting: 100 000 m, False Northing: -6,100,000 m. Example of a point's coordinates in different coordinate systems: x (Northing) = 6,200,000.000; y (Easting) = 1,300,000.000 in 'RT 90 2.5 gon V 0:-15' x (Northing) = 6,195,783.588; y (Easting) = 1,440,736.999 in 'RT 90 5 gon V 0:-15' x (Northing) = 95,783.588; y (Easting) = 40,736.999 in 'RT 90 5 gon V 61:-1'."

"SWEREF 99 is a Swedish realization of ETRS 89. The processing of the GPS data was performed according to the EUREF guidelines and was based on observations made on permanent reference stations in Sweden (SWEPOS), Denmark, Finland (FinnRef), and Norway (SATREF) during the GPS-weeks 1014-1019 (June-July 1999).

SWEREF 99 coincides with WGS 84[G730] and WGS 84[G873] within some decimeters. Coordinates can be transformed from the Swedish coordinate datum RT 90, to SWEREF 99 through a 7-parameter transformation given below (estimated accuracy of 7 cm, 1 sigma, 2D). The ellipsoid used with SWEREF 99 is GRS 80: a = 63781371/f = 298.257222101. SWEREF 99 replaces SWEREF 93 (the former realization of ETRS 89). If one prefers to define a transformation in the direction RT 90 to SWEREF 99, use the following parameters: ΔX= +414.1 m, R_x = +0.855 arc seconds, ΔY = +41.3 m R_y = - 2.141 arc seconds, ΔZ = +603.1 m R_z = +7.022 arc seconds, and δ = 0.0 ppm (scale = 1.0)."

For example latitude, longitude and height above the Bessel 1841 ellipsoid in RT 90: φ = 58° 00' 01.213296" λ = 17° 00' 11.683659" h = –5.397 m, latitude, longitude and height above the GRS 80 ellipsoid in SWEREF 99: φ = 58° 00' 00.0", λ = 17° 00' 00.0" h = 30.000 m. Much to my surprise, when I carefully examined the published parameters, I realized that the rotation convention is the same as that used by the United States and by Australia. Thanks to Professor Lars Sjöberg now of the Geodesy Group at the Royal Institute of Technology in Stockholm for his patient help many years ago.

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